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Exploring Approaches to Decision-Making in the Land Sector

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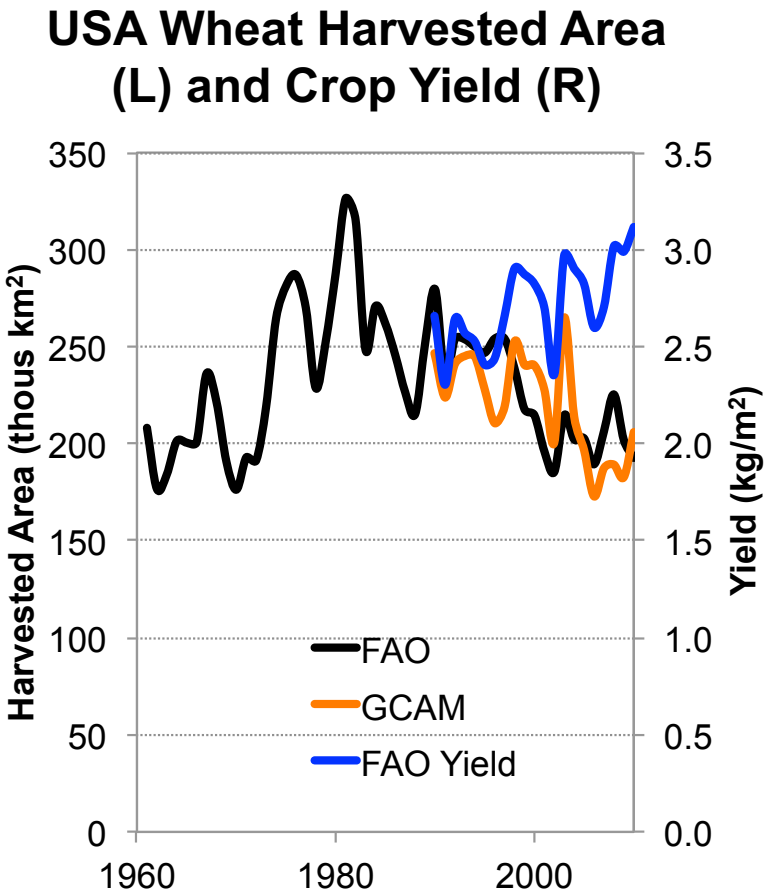
Motivation: What we assume about yields in a given year influences land decisions.

- Two recent papers have analyzed a hindcast in GCAM (Calvin et al., 2017; Snyder et al, 2017).

- **Key findings:**
  - GCAM replicates trends in production and harvested area, when relevant energy and environmental policies are included.
  - But, GCAM reallocates land in response to changes in yield, over-compensating for yield variability.
  - Performance improves when we use forecasted yields.



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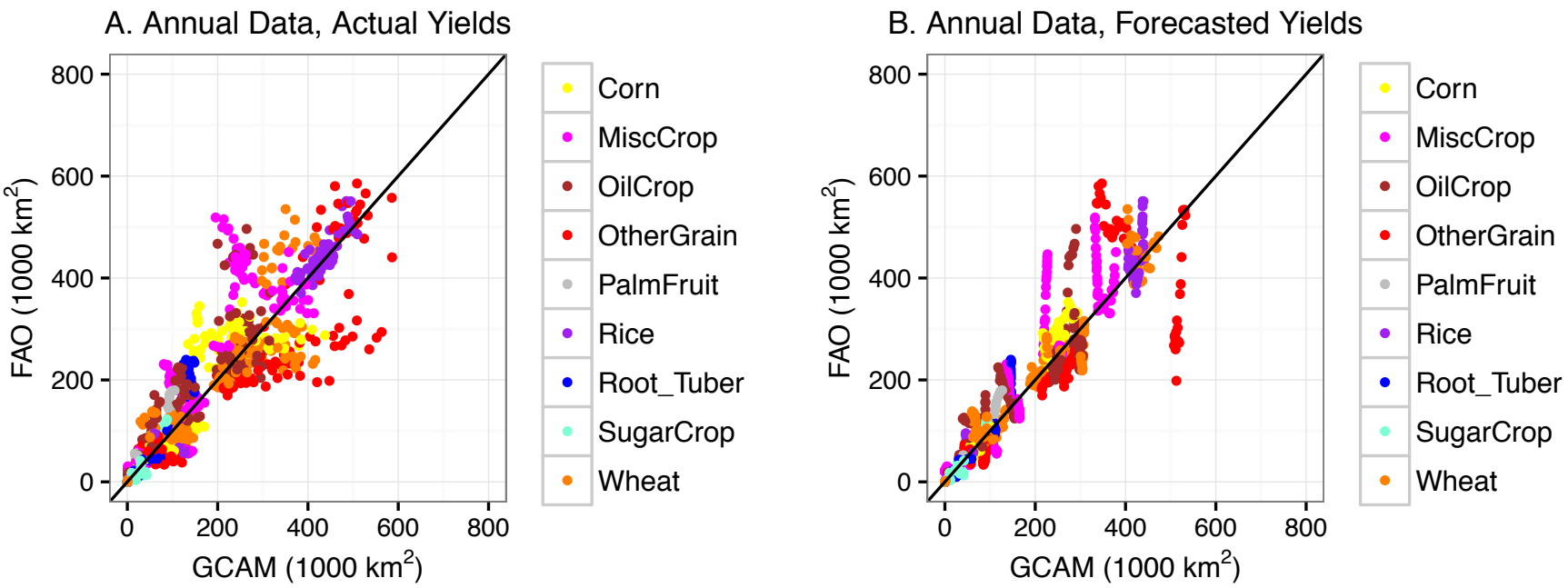
Land Allocation using Actual Yields (left) and Forecasted Yields (right)



Calvin et al. (2017)

GCAM's Land Use Decision-Making

- Land allocation decisions are made based on expected profit.
  - Land owners allocate land across a variety of uses in order to maximize profit.
  - Profits depend on the **price** of the commodity, agricultural **yield**, and the **cost** of production.

- GCAM operates on an annual (or multi-annual) time step.
  - The **price** used for decision-making is the market clearing price.
  - The **yield** used at the planting stage is the same used at the harvest stage.
  - Implicitly, this means that land-owners in GCAM have **perfect information** about the future within a given time step.

- In the real world, land owners don't know the future. Instead, they form expectations about **yield** and **price**.

The implications of moving from perfect information to imperfect information

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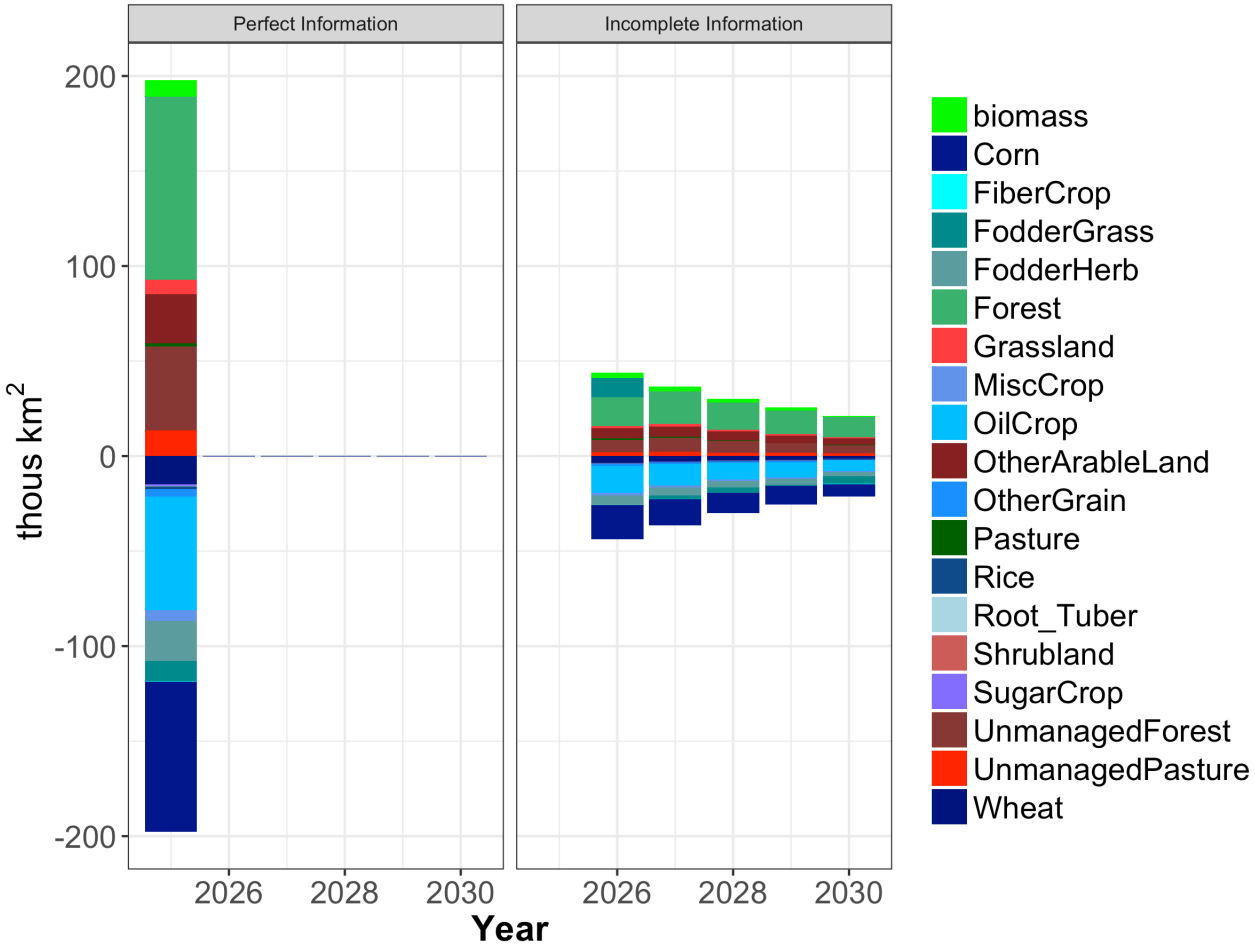
Change in USA AEZ10 Land Allocation when a shock is included in 2025



gcamland: an offline land allocation model

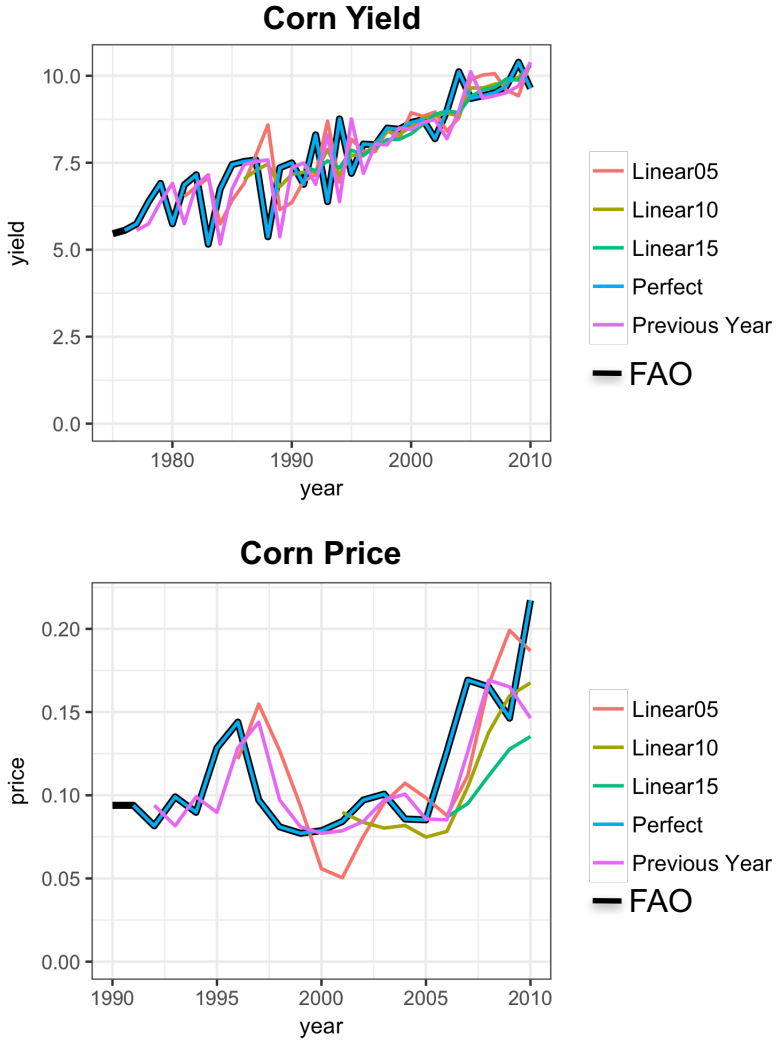
- Approach: Isolate the land allocation mechanism, so we can use observed prices (and yields).
- Time horizon: All simulations use 1975 as the final calibration period and then run in annual time steps through 2010.
- Data for 1976-2010:
  - USA producer price from the ***FAO*** for price*
  - USA yield from the ***FAO*** for yield

* FAO only has prices starting in 1991, so we are using constant prices from 1976-1991

Using hindcast experiments to parameterize the land allocation decisions within GCAM

- Simulations:

Scenario	Yield/price source
Perfect	FAO data for current year
Previous Year	FAO data for the previous year
Linear05	Linear extrapolation based on 5 most recent years of FAO data
Linear10	Linear extrapolation based on 10 most recent years of FAO data
Linear15	Linear extrapolation based on 15 most recent years of FAO data



Under perfect expectations, we see more variability in corn land allocation than the observations.

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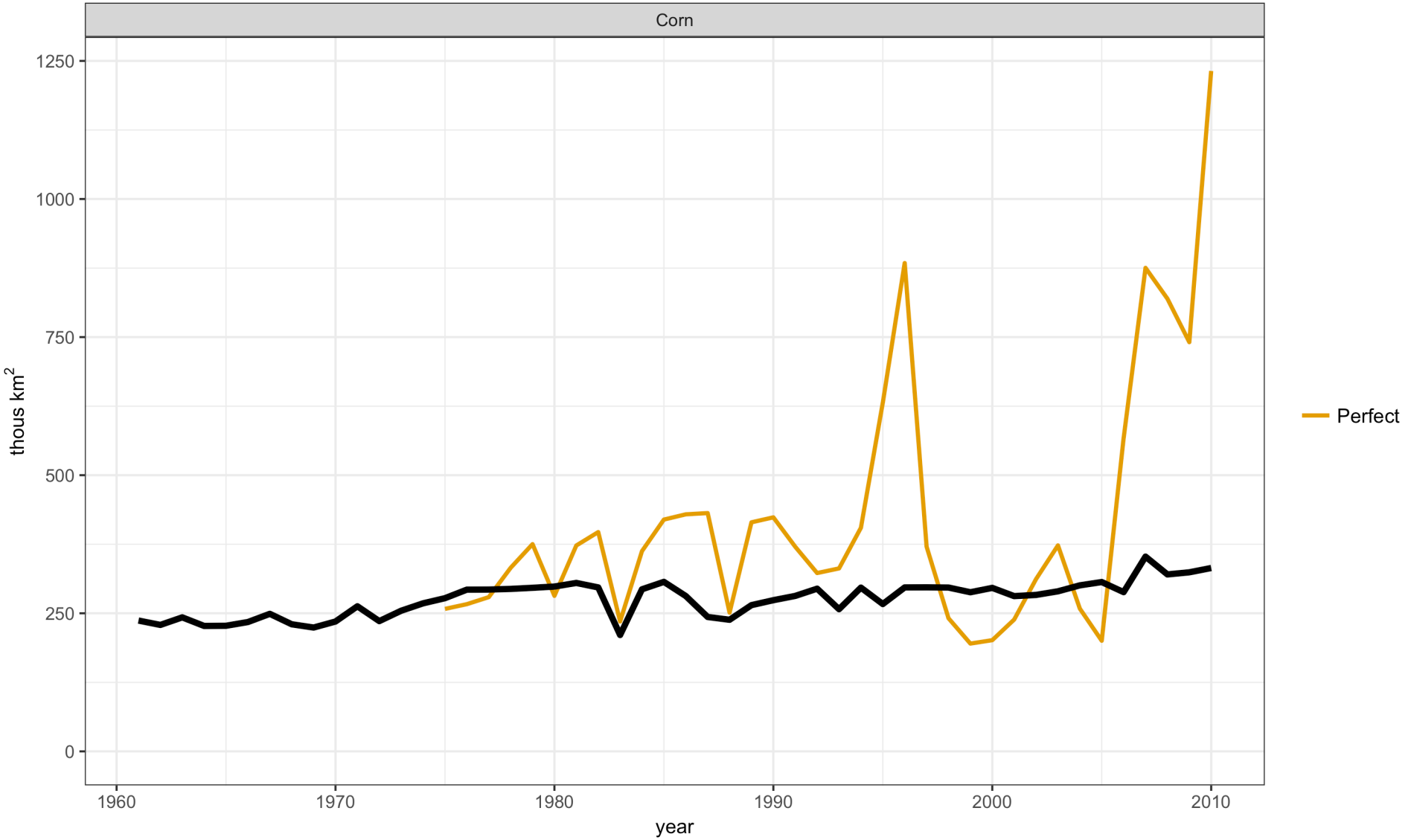

Increases in land allocation are correlated with increases in yield…

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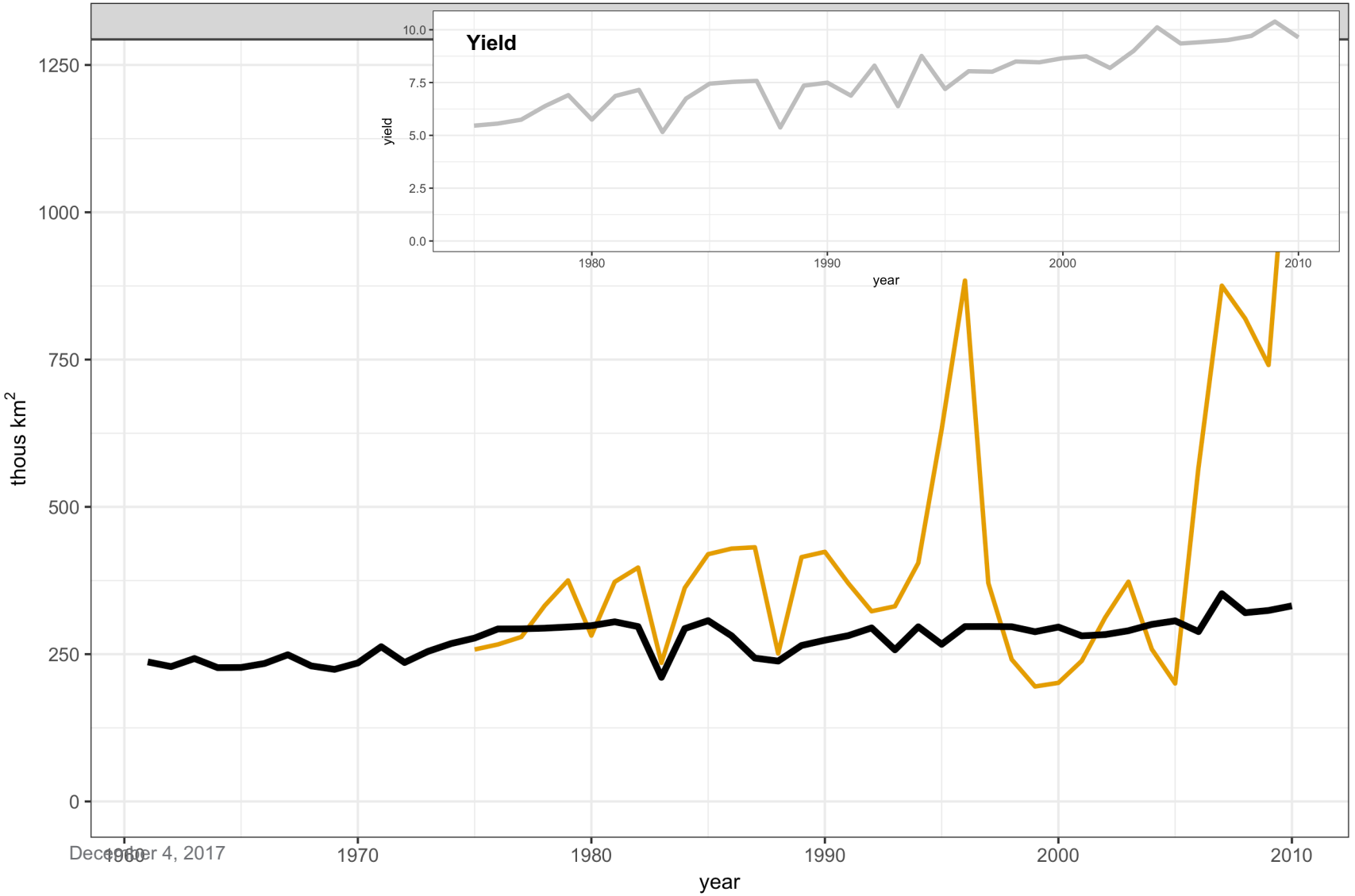

Increases in land allocation are correlated with increases in yield and price.

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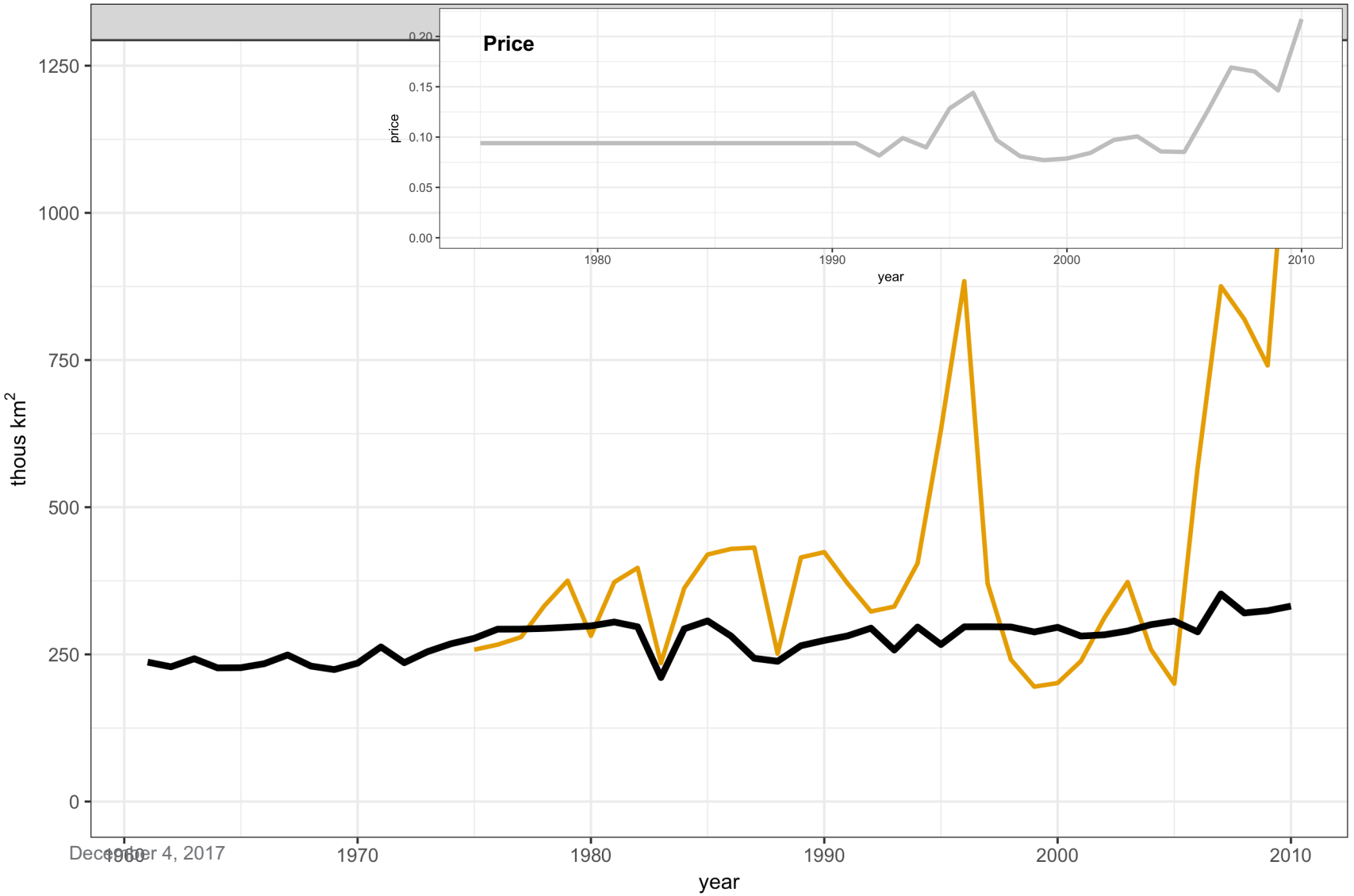

Using the previous year's information merely shifts the peaks by a year.

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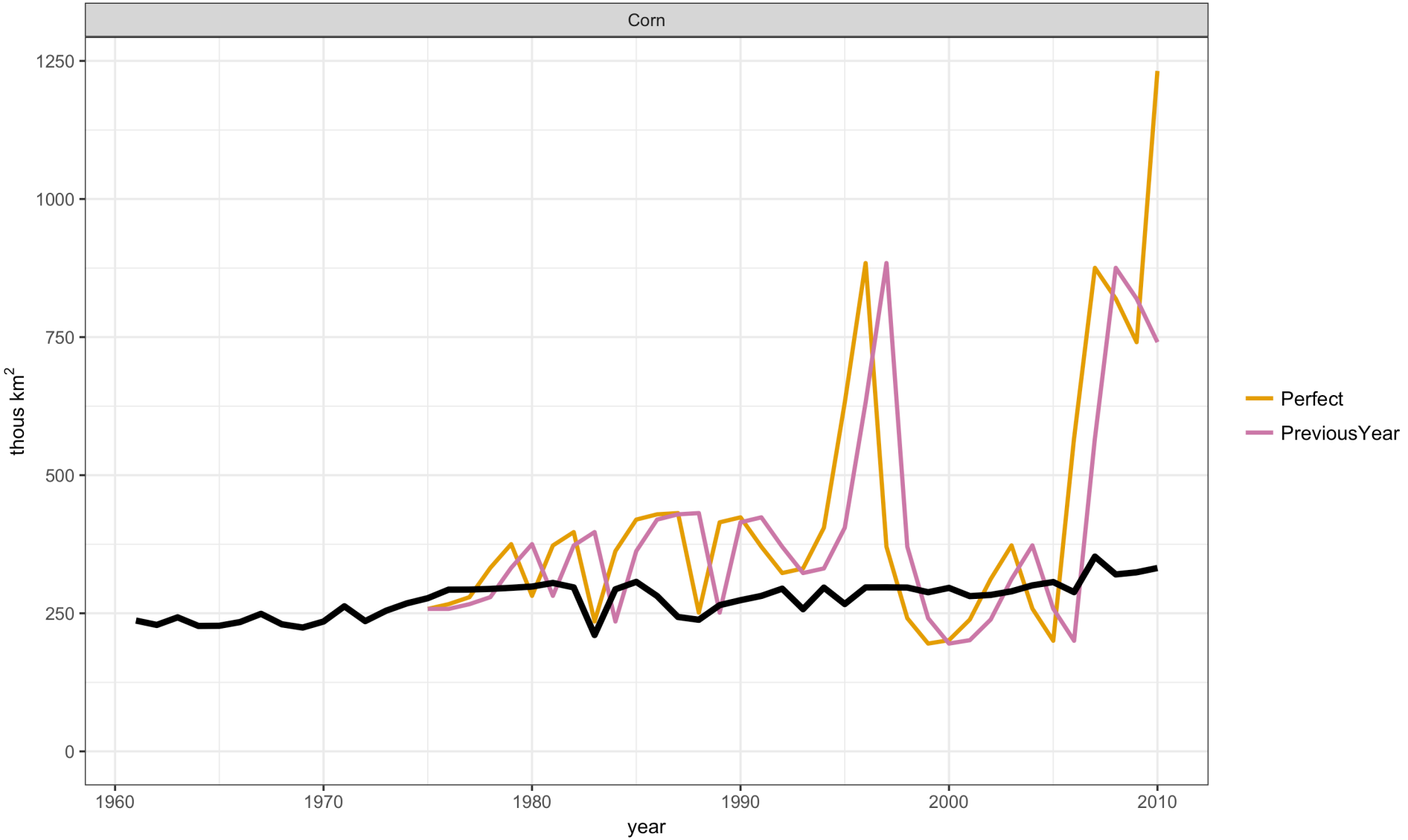
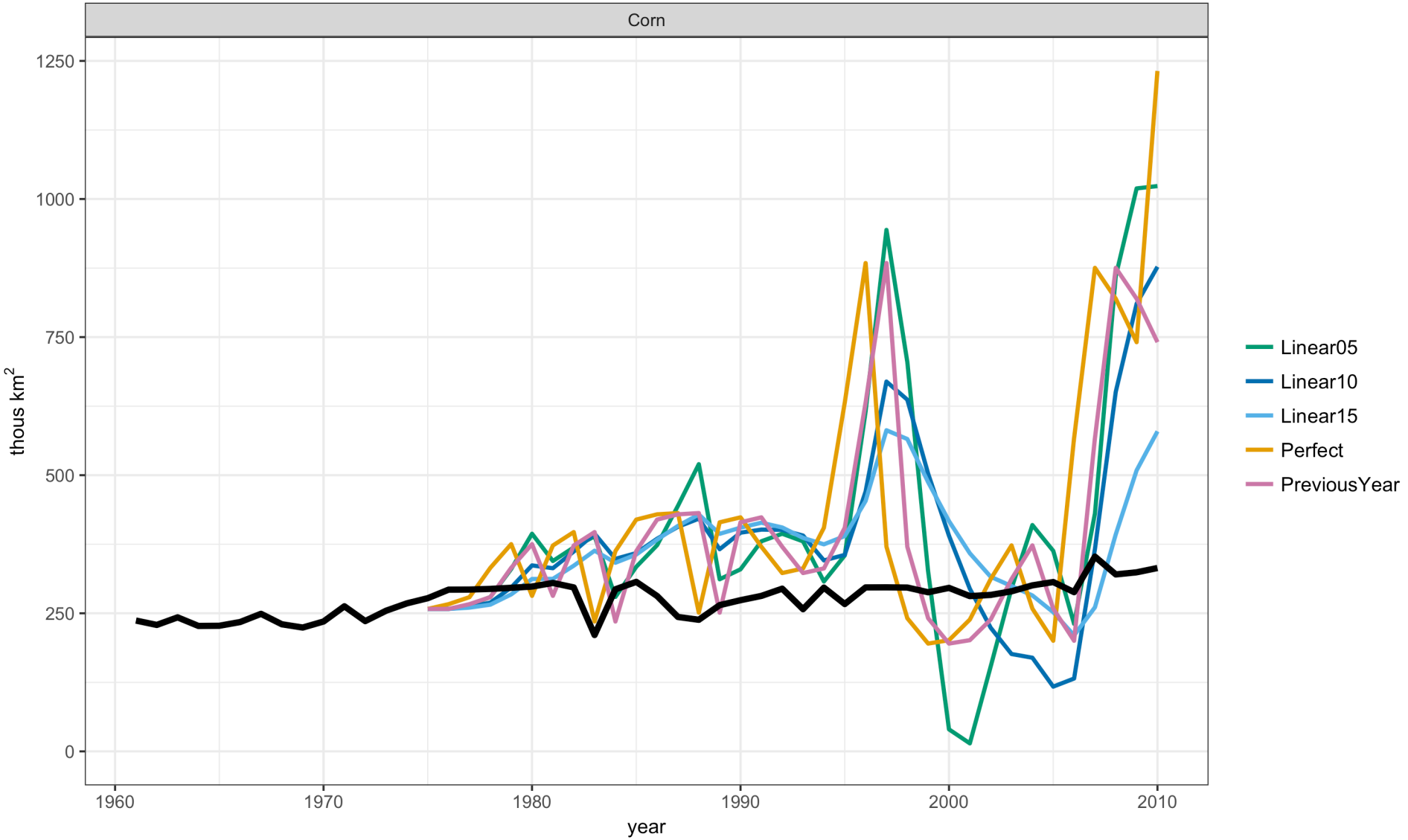
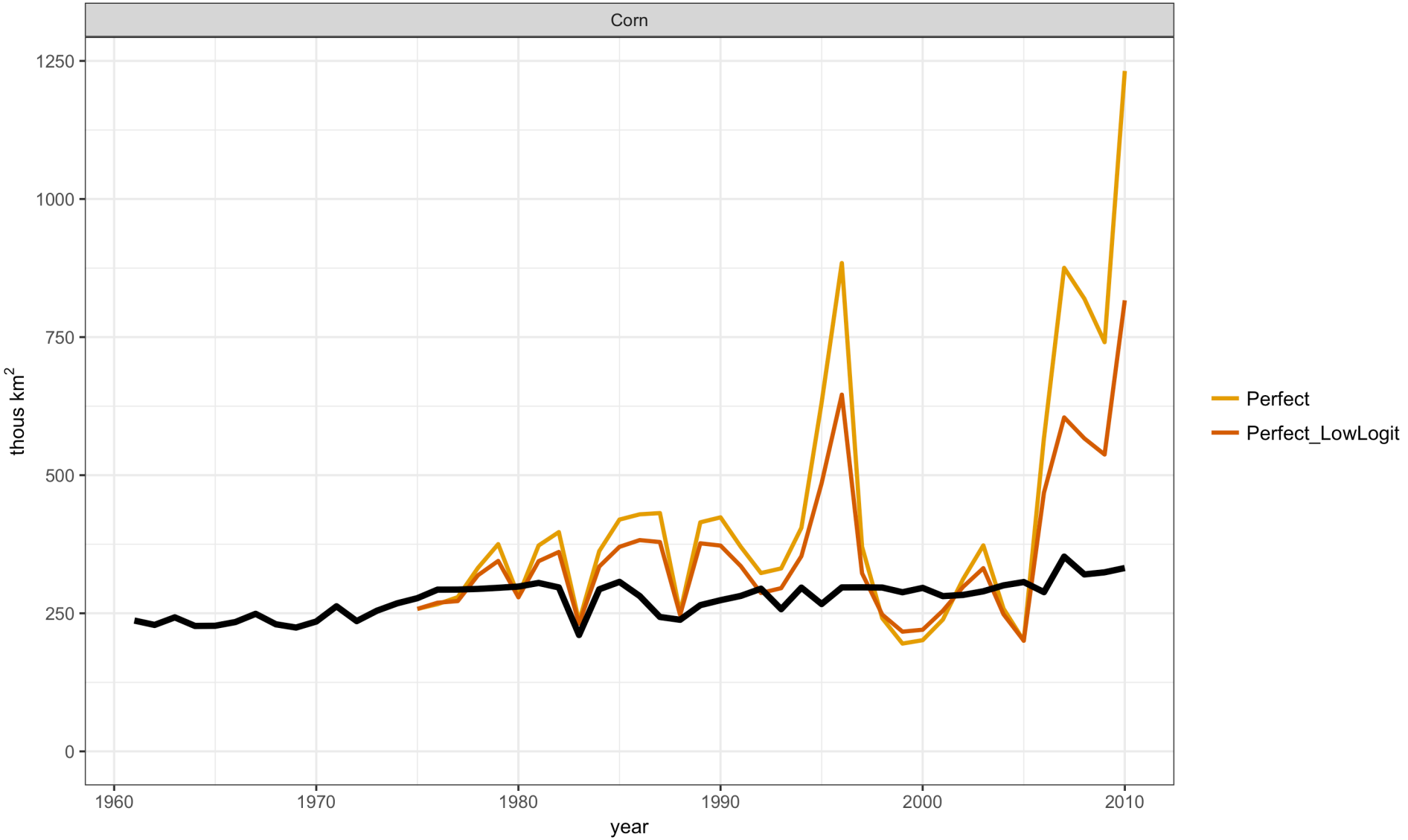


As you include more previous information in the decision, the response becomes more muted, but the model still responds too much.



We can use the offline land model to test alternative decision-making frameworks and expectation schemes.



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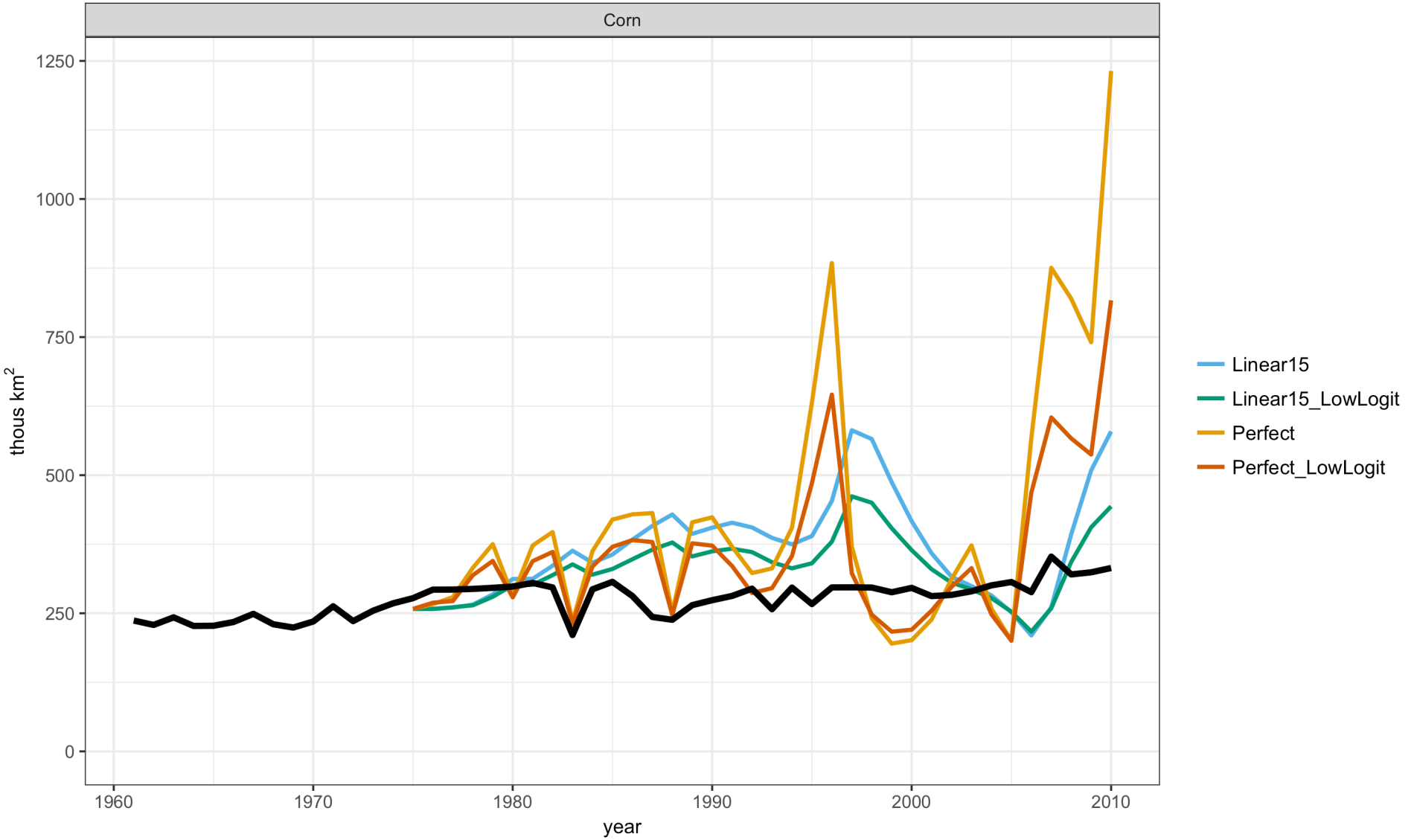

Summary & Future Research

- Summary:
  - The current version of GCAM was designed for long time steps (5-15 years) and performs fairly well at these time scales.
  - As we begin to examine shorter time steps, and incorporate variability, some changes are needed to the parameterization of the land allocation mechanism.
  - We've started using hindcast experiments to test the fidelity of parameters and assumptions within GCAM.

- Future Research:
  - Use more formal parameter estimation techniques (e.g., multinomial logit regression, Monte Carlo analysis) using the offline land model to find sets of assumptions that reproduce historical observations.
  - Examine the implications of these different assumptions in the future period, and the effect of land allocation decisions on other sectors.

Questions?